

SECTION 4

ENVIRONMENTAL INVENTORY AND ANALYSIS

A. GEOLOGY, SOILS, AND TOPOGRAPHY

Brookline's 6.8 square miles (4,355.4 acres) are located in the lowlands of the Boston Basin, on average between 50 and 140 feet above sea level. However, the many hills that spread across the landscape are among the highest points in the basin. At 340 feet, Single Tree (also known as Lyman) Hill is the highest point in Town.

Continental drift, volcanoes, sea level changes, glaciers, and humans have acted on the landscape over the years to shape the bedrock and surficial geology of Brookline into its present form. The bedrock that forms the Town's foundation is of three varieties: Roxbury conglomerate, Cambridge slate, and Brighton melaphyre. The bedrock geology of North Brookline is not well known and outcrops of Cambridge slate, which appears as a dark bluish gray to brownish gray shale or slate, can be seen between Beacon Street and Clark Road and east of Cleveland Circle to Tappan Street. Brighton melaphyre is a greenish, brownish, or purplish basaltic volcanic rock. Outcrops can be seen near Lost Pond. Probably the best known is the Roxbury conglomerate or "puddingstone" on which most of South Brookline rests. Numerous outcrops of puddingstone, which consists of waterworn rocks cemented together with other minerals, can be seen throughout this part of Town, including in the D. Blakely Hoar Sanctuary.

Glaciers scoured the land 10,000 to 12,000 years ago. When the ice sheets expanded across the landscape, they removed all plant and animal life. The coastal areas of New England sank below sea level due to the great weight of the ice. When the glaciers receded, the major features of the landscape we see today remained. The most prominent features are the drumlins, hills composed of glacial till (rock and clay) formed in the shape of an inverted teaspoon and pointing in the direction of the glacial flow.

Brookline has seven major drumlins: Corey Hill, Fisher Hill, Single Tree Hill, Walnut Hill, Larz Anderson Park Hill, Aspinwall Hill, and Mount Walley (Table 3). In addition to the till, glaciers left deposits of sand and gravel, particularly in the northern and southwestern portions of the Town.

Table 3
Brookline's Drumlins
Elevations above sea level

Aspinwall Hill	240 feet
Corey Hill	260 feet
Fisher Hill	270 feet
Larz Anderson Park Hill	290 feet
Mount Walley	310 feet
Single Tree Hill	340 feet
Walnut Hill	310 feet

Glaciation also left kettle ponds, such as Lost Pond, and wetland areas across the Town.

In areas where bedrock is close to the surface, there is a potential for flooding during heavy rains due to insufficient soil cover. Soil acts like a sponge to soak up and retain rain water. Typically, deeper soils have a greater potential to absorb water. When the soil reaches its maximum absorption capacity, water moves through the soil, and then migrates over the bedrock to lower elevations. In many cases, the lowest point may be the basement of a house. Many bedrock areas have steep slopes. Removing vegetative cover on steep slopes will increase the chance of soil erosion. Future developments should consider the depth to and location of bedrock because it influences site drainage and drainage patterns in a given area.

Soils

The surface geology of Brookline is the result of the material or debris left behind by glaciers, erosion and sedimentation, and human alterations. In general, Brookline soils are either glacial till or sand and gravel. Soils are classified by the U.S. Department of Agriculture's Natural Resources Conservation Service, based on physical and chemical properties in their horizons or layers, such as color, texture, structure, etc.

Most of North Brookline is classified as one of several different types of urban land complexes. Urban land complexes are defined as areas where 75 percent or more of the land is covered with impervious surfaces. Impervious surfaces consist of buildings, roadways, parking lots, and are typical of

business, commercial, and industrial areas. Essentially all the rain that falls in these areas runs off into storm drains that are required to handle the excess water. Examples of these areas are on Beacon Street at Washington Square and Coolidge Corner. It is difficult to determine soil types in these areas because much of the soil has been mixed up, removed, replaced with other materials, and resides under pavement, concrete, and/or buildings. Development limitations vary because soil types are relatively unknown below the impervious surfaces that cover most of North Brookline. When the impervious cover is removed there is a risk of erosion. Without protective controls (e.g., hay bales, silt fences or other methods), eroded soils can wash into the storm drain and discharge into water resource areas like Hall's Pond, Leverett Pond, the Muddy River, and the Charles River. Erosion and sediment control practices should be implemented during all phases of construction in these areas. Future developments/redevelopments should try to reduce the amount of impervious areas where practical and try to incorporate practices to retain rain water onsite and reduce the amount of runoff to the storm drain system.

In South Brookline, there are a variety of different soil types. Hydric or wetland soils are generally classified as Swansea muck, a deep (52 inches or greater) organic soil with a seasonally high water table. Much of Putterham Meadows rests on this soil. Allandale Farm contains prime agricultural soils, including soils in the Canton, Scituate, and Sudbury series. Prime agricultural soils, including the Sudbury and Merrimac series, are also located south of Sargent's Pond on undeveloped land, which has been used in the past for cultivation. Residential development limitations on agricultural soils range from slight to moderate. Putterham Woods and Dane Park are characterized by soils in the Hollis series, which are comprised of a thin layer of loamy soil over shallow bedrock. The area between Fernwood Circle and Warren Street is characterized by soils in the Montauk, Hollis, and Sudbury series. Generally, they present moderate limitations on residential development due to wetness.

Soils in the Fisher Hill Reservoir area are classified as Newport Urban Land Complex, which also presents moderate challenges to residential development due to slope and wetness. The Bournewood Hospital site is located on Charlton Hollis Urban Land Complex. Development limitations are generally slight except where there are rock outcrops.

B. LANDSCAPE CHARACTER

The combination of bedrock outcrops and glacial features, drumlins rising above relatively flat glacial deposits and extensive remnants wetlands, and small streams, continue to affect Brookline's patterns of development. As Brookline's landscape is largely developed, most of the areas that remain undeveloped are those where natural features have made development difficult.

The hills which were earlier claimed for estates and large homes remain significant, but only a few serve public open space needs. Larz Anderson and Summit Hill are both beloved places to see the sky, watch sunsets and the view the skyline. Larz Anderson is one of the best sledding hills in Town. Skyline Park, completed in 2008, provides public access to a hill with a scenic vista. The Fisher Hill Reservoir has recently transferred in ownership from the State to the Town of Brookline, and will eventually be open to the public as parkland and open space. This area could be landscaped in a way that would give visitors a direct view of the sunset. Public access to the top of those hills that still include open space would be of great value.

The rock outcrops, particularly the Roxbury conglomerate in South Brookline, are unique features of Town. Because they have shaped and somewhat limited development, a number of the public open spaces in this part of Town contain interesting outcrops, including Dane Park, Putterham Woods, Walnut Hills Cemetery, and the D. Blakely Hoar Sanctuary. However, the outcrops on private property are vulnerable to destruction from expansions and other modifications.

At Allandale Farm and on large properties that were once part of larger country estates, small portions of the flat areas and gentle slopes which were not historical wetlands remain as fields or meadows. However, none of these fields or meadows currently are accessible for members of the public who might wish to explore these natural habitats. Some can be viewed from public streets and sidewalks, but even their role as a viewshed are not protected. Preservation of agricultural land and meadow lands would serve the public, particularly if some limited public access could be granted within them.

In North Brookline, there was once a cedar swamp, salt marshes, fresh water wetlands, and streams associated with the Charles River and

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Muddy River. Today, North Brookline is extensively developed, with Hall's Pond and a number of parks and playgrounds acting as the only natural features. However, many of the parks, including Amory Playground, Griggs Park, Brookline Avenue Playground, and Boylston Street Playground were built on poorly drained or filled land.

In South Brookline, the draining and filling of wetlands, as well as building beside small open sections of streams and wetlands, have caused water problems for residents. Putterham Meadows, once a wetland, was converted to a public golf course, the Robert T. Lynch Golf Course at Putterham Meadows, but still plays a vital role in managing the water. A recent project by the Town, on Golf Course property, included drainage and stream improvements, including removing a stream crossing and retaining walls and restoring portions of the stream bank, with future dredging and stream daylighting planned. Areas such as Button Village and the Baker School District were also built on fill.

Almost all of the Town's landscape is actively maintained. Even the natural parts of the sanctuaries must be maintained for safety and trail access, as well as to control diseases such as the hemlock woolly adelgid. Privately owned and maintained landscapes such as gardens, trees, shrubs and lawns are often considered to be valuable "green" assets to the whole Town. However, these landscaped areas are at risk of development or loss. Infill housing, tear-downs and expansion of existing homes has been accompanied by loss of landscaped grounds in neighborhoods which had not, until recently, been considered to be vulnerable to such changes. Even the creation of larger parking areas and driveways decrease the quality of green space in denser residential neighborhoods. Paving over of lawns, particularly front lawns, may also decrease the aesthetics of neighborhoods and residential streets.

C. WATER RESOURCES

Although the Charles River does not flow through Town, Brookline is located entirely within the Charles River watershed, meaning that all rain and snow that falls within the Town boundaries eventually drains to the Charles River. The watershed area is 308 square miles and consists of 35 communities within its boundaries. Classified as a Class B Warm Water by the State, the Charles River is designated as a habitat for fish, other aquatic life,

and wildlife, as well as suitable for primary contact recreation, such as swimming, fishing, windsurfing, and secondary contact recreation, such as canoeing, boating, kayaking, and sailing. The last nine miles of river, known as the Charles River Basin, is one of the most widely used recreational areas in the country.

Some drainage from North Brookline reaches the Charles River directly. The rest is conveyed indirectly through subwatersheds draining to seven other destinations which ultimately discharge to the Charles River. These include the Muddy River, Stony Brook and Saw Mill Brook. Approximately half of the Town's stormwater drains to the Muddy River. En route to these drainage destinations, some stormwater goes through Hall's Pond, Sargent's Pond, and Lost Pond in Brookline, as well as Jamaica Pond in Boston and Hammond Pond in Newton.

The Muddy River flows 3.5 miles starting at its headwaters or source, Jamaica Pond, a large natural kettle pond located in Boston. It flows north through a series of small ponds, Ward Pond, Willow Pond, and Leverett Pond, and the Back Bay Fens, and ends at the Charles River. The Muddy River drains an area of 5.6 square miles that encompasses parts of Boston, Brookline and Newton.

The Muddy River has two major tributaries; Village Brook and Tannery Brook. Until the creation of the Charles River Dam at the Museum of Science in the early 1900s, large expanses of tidal marsh bordered the Muddy River up to the present day location of Route 9.

From Jamaica Pond to Route 9, a distance of 0.5 miles, the river elevation drops 57 feet, and flow is moderate to rapid. Below Route 9, the river profile is relatively flat. As Brookline developed, stream channels were constructed and eventually put into pipes. Today, all of Tannery Brook and most of Village Brook are buried underground and serve as major stormwater drainage basins. Both Sargent's Pond and Brookline Reservoir in Brookline and Chestnut Hill Reservoir on the boundary of Boston and Brookline contribute flow to the Muddy River via underground pipes.

For many years, human sewage was discharged directly to the streams and rivers. When the population was small and the Muddy and Charles Rivers were still relatively natural, this method of sewage disposal was adequate. However,

as population grew and the hydrology of the Muddy was altered by the construction of mill dams, the river, and particularly the marsh areas, became stagnant cesspools. Faced with these conditions, the decision was made to address them by the introduction of a public sewage system, the creation of a dam at the mouth of the Charles River, filling of the marshes, and creation of Frederick Law Olmsted's Emerald Necklace park system. During the 1880s, the Muddy River was completely reshaped and re-landscaped according to Olmsted's vision. Today, the Muddy River serves Boston and Brookline as a major park, and provides fisheries and wildlife habitat and flood storage capacity. The Emerald Necklace park system includes linear parks and paved pathways on both banks of the Muddy River, starting from the confluence with the Charles River to the headwaters in Jamaica Pond. This provides for both active (fishing, running, biking, ball fields) and passive (bird watching, walking, scenic vistas) recreation along the river's edge. Very little water-related activity takes place within the river because of its relatively narrow width, shallow depths, and restricted access.

Similar to the Charles River, the Muddy River is classified as a Class B Warm Water that is suitable for primary and secondary contact recreation and serves as habitat for fisheries, other aquatic life and wildlife. During dry weather when there has been no or little rain, water quality in the tributary is generally good; meeting State water quality standards for Class B water. However, due to urban runoff, oil spills, and illegal, undocumented sewage discharges, water quality remains poor especially after a rainstorm. The river has lost significant flood carrying capacity due to sediment build-up, primarily from storm-water runoff and streambank erosion.

Watershed Protection Efforts

Numerous ongoing efforts are occurring on federal, state, and local levels to protect and enhance Brookline's water resources, which are vital for flood control, storm damage protection, wildlife and fisheries habitat, and recreational uses. Over the past decade, the Charles River watershed has received considerable attention for the numerous mitigation and restoration projects that surround this body of

Figure 4. Ten Tips for Keeping Our Rivers and Ponds Clean

- 1) Don't trash the water. Litter always goes somewhere - usually into our storm drains, then directly to our rivers and ponds. Do your part, pick up after yourself and participate in local cleanups.
- 2) Pick up your pet's waste. One in five households in this state has a dog. Imagine if all that pet waste was left on the ground to wash into our storm drains and into the waterways where we swim and boat.
- 3) Don't feed geese or other waterfowl and wildlife. Goose fecal matter is a major source of contamination to our rivers, and feeding geese encourages overpopulation of these waterfowl.
- 4) Keep your lawn and garden "green." Overuse of pesticides and fertilizers, and use before rain or watering means that these toxins end up in our waterways, causing damage to the ecosystem and encouraging growth of non-native, invasive plant species.
- 5) Reuse your rainwater. Collect rainwater from your roof with a cistern or rain barrel and then use it to water your garden, which will conserve drinkable water and decrease the polluted water that enters storm drains. Direct your gutter spouts away from paved surfaces to decrease runoff.
- 6) Reduce paved surfaces. When developing or redeveloping your property, minimize the size of your driveway and other non-pervious surfaces. Consider using permeable material such as pavers, gravel, or newer available technologies like porous or permeable asphalt and concrete, instead of traditional pavement.
- 7) Keep oil off the streets. Leaking oil drops onto the street and is eventually rinsed into a storm drain, which discharges to the nearest waterway. Fix oil leaks promptly, and never dump used oil down a storm drain.
- 8) Let the professionals wash your car. If you wash your car at home, all that soapy, dirty water ends up in the storm drain and runoffs to the rivers and ponds. Professional car washes are required to treat and recycle water used, and they use much less water than washing your car at home.
- 9) Get your septic system pumped and inspected regularly. Malfunctioning septic systems can contaminate surface water and groundwater resources or cause backups at the site. To prevent this, have your system inspected regularly.
- 10) Support open space protection. One of the most effective ways to keep our rivers and ponds clean is to allow rain to percolate or infiltrate into the ground instead of running off our streets and other paved surfaces. Plants, trees and soils are natural filters of pollutants so in order to keep our rivers and ponds clean, we must protect open space.

water. The US EPA - New England launched in 1995 the goal of a swimmable and fishable river by Earth Day 2005. A significant player and advocate for the river is the Charles River Watershed Association (CRWA), a non-profit organization established in 1965 to protect, preserve and enhance the health, beauty and accessibility of the river and its tributaries. CRWA's numerous programs in watershed management, water law and policy, water quality, stormwater, parklands, and land use have been instrumental in the cleanup of the river and its tributaries. A cornerstone program of the association is its volunteer water quality monitoring program conducted on a monthly basis at 37 sites along the entire length of the river and two tributaries including one site on the Muddy River.

Efforts to improve water quality, flood capacity and habitat conditions of the Muddy River are also of great importance. The Muddy River is one of the most polluted tributaries to the Charles River discharging at the Esplanade area, which is the most popular recreational area of the Basin. The chain does not end there since the Charles River discharges into Boston Harbor, potentially further impacting the water quality of the Harbor. The Muddy River is a significant historic and cultural landscape serving as the centerpiece of Olmsted's Emerald Necklace Park system and for its proximity to numerous higher education institutions and the Longwood medical area. The MA Executive Office of Environmental Affairs, the cities of Boston and Brookline, businesses, institutions, and environmental organizations, such as the Muddy River Management and Maintenance Oversight Committee, Emerald Necklace Conservancy and Brookline GreenSpace Alliance, are working together to restore and protect the historical and ecological integrity of the Muddy River (see map on pg. 50).

Additional Surface Water Resources

Historical maps of Brookline show nine major stream systems in addition to the Muddy River. The nine streams are Saw Mill Brook, South Meadow Brook, Village Brook, Tannery Brook, Smelt Brook, Stony Brook, Chestnut Street Brook, South Branch of Village Brook, and Swallow Brook. In addition, there is an unnamed stream between Goddard Ave. and Sargent Pond. Most of these streams have been placed in pipes and are no longer visible. Those that are visible have been altered by channelization for agriculture or mosquito control.

Segments of South Meadow Brook, Saw Mill Brook, Village Brook, and the unnamed stream are still open.

Two branches of Saw Mill Brook begin in Brookline and drain southwestward to the Charles River in West Roxbury. The east branch starts in a wooded swamp located in the D. Blakely Hoar Sanctuary and flows through West Roxbury to the river. The west branch originates east of Newton Street near the Newton border, receives drainage from The Country Club and the Robert T. Lynch Golf Course at Putterham Meadows, and flows through Newton and West Roxbury where it meets with the east branch.

Stony Brook, which originates in Boston, flows to the Charles River through West Roxbury. Stormwater drainage from the southeast corner of Brookline contributes to the Stony Brook subbasin. Historical maps indicate that a pond existed in the area presently occupied by Bournewood Hospital.

The drainage from Lost Pond in South Brookline was redirected into South Meadow Brook by an abutter named Frederick Fennard. South Meadow Brook ran through his property so he diverted the drainage from Lost Pond to the Brook in an attempt to draw upland species to the pond. However, Lost Pond did not have the right conditions for upland species since it is a peat bog and the decomposed plant material that covers most of the Pond is very acidic in nature.

Originally, the Charles River subbasin was also composed of Smelt Brook and Cedar Swamp. Smelt Brook was located in the vicinity of Naples Street and formed the northwest boundary of Judge Samuel Sewall's arable land, which he called "Brookline." In order to protect Smelt Brook from dumping and other polluting activities it was channeled into a pipe and is no longer visible above ground but drains to the Charles River. Cedar Swamp, a large wetland where Amory Playground and Hall's Pond are now located, drained directly to the Charles River through a small brook. Today, Hall's Pond and its adjacent wetlands and the Amory Woods wetlands are all that remains of Cedar Swamp. Drainage from Hall's Pond reaches the Charles River via an underground pipe and wet conditions at Amory Playground and flooding continue to remind us of the land's history. The Hall's pond restoration in 2002 and ongoing maintenance efforts have considerably improved the water quality of the water that reaches the Charles River.

Ponds

A 1641 map indicates that there were six ponds and no lakes in Brookline. After the arrival of the colonists, ponds were created for water supply and agriculture. It is not possible to determine which of the six ponds were natural or man-made; today, Lost Pond and Hall's Pond are the only ponds remaining from 1641. Hall's Pond has been reduced in size by filling and Lost Pond is gradually shrinking due to eutrophication, the overgrowth of vegetation, both aquatic and terrestrial, due to high nutrient levels. Sargent's Pond, Larz Anderson Park Lagoon, and the Brookline Reservoir are the major bodies of surface water that have been created. Brookline Reservoir was created in the 1840's by the city of Boston as a drinking water reservoir and was acquired in 1903 by the Town of Brookline. It was taken off-line when the Chestnut Hill Reservoir was established. Today it provides recreational benefits including fishing, walking and running on a gravel pathway encircling the perimeter of the reservoir. Small ponds also exist at The Country Club, the Robert T. Lynch Golf Course at Putterham Meadows, and Allandale Farm. As mentioned previously, Ward Pond, Willow Pond, and Leverett Pond located on the Muddy River are part of the Emerald Necklace park system that is shared with Boston.

Groundwater or Aquifers

Groundwater flows are determined by the shape and the slope of bedrock and by the type of soils overlying the bedrock. Brookline is typical of the region, having soils that are a complex mix of glacial drift deposits. Groundwater is typically found in sand and gravel deposits. In general, groundwater flows tend to follow surface water drainage divides, but where surface water has been diverted, this may not be the case. Groundwater contamination has been identified in some locations, which pose threats to surface waters when it migrates toward ponds and streams, or into storm drains. Groundwater resources were historically important to Brookline as a source of drinking water, known as aquifer recharge areas. These areas provided a high yield of groundwater for the Town's drinking water supply. The Chestnut Hill Reservoir was taken off line in 1978 and the Town is presently served by the Quabbin Reservoir located in central Massachusetts, as well as other outside reservoirs that are members of the Massachusetts Water Resources Authority.

Stormwater

In the natural water cycle, precipitation falls down on Brookline and provides water for trees, plants, fields, lawns and surface waters. A significant portion of that intercepted precipitation evaporates back into the atmosphere; another portion of rain soaks into the soil, which recharges our aquifers or underground water supplies. This groundwater provides a source of water for local wetlands and streams. Water that reaches the surface eventually evaporates and continues the hydrologic cycle. Today, the water cycle has been vastly altered due to population growth and development. Instead of recharging groundwater, a large amount of rain falls on impervious areas, such as rooftops, roads, driveways, parking lots and streets, and flows directly into the stormwater drainage system made up of catch basins and series of connected pipes that discharge into the Muddy River or other tributaries, which eventually reaches the Charles River.

This altered, or "man-made," water cycle creates three significant interrelated problems: reduced infiltration of water into the soils; increased pollution to lakes, ponds, wetlands, and streams; and increased flooding.

1. Reduced infiltration of water into the soil decreases the water supply to plants and trees and groundwater, which minimizes the amount of groundwater available to recharge ponds, lakes, and rivers.
2. Unfiltered by vegetation and soil, stormwater is highly polluted. Water quality sampling of the Muddy River and the Charles River shows that these streams have high pollutant levels of bacteria, oil and grease, metals and sediments after storm events. Rain collects fertilizers, trash, oil and grease, pet and wildlife waste, and other pollutants on paved surfaces and discharges them into the storm drain system, which leads to the Charles River. By the time stormwater runoff reaches its discharge point, it has become the biggest source of pollution to an urban river, lake or stream.
3. High peak flow and high volume of runoff increases the possibility of flooding. Water that used to meander across a bumpy, rutted landscape covered with plants and gullies is now piped, reaching the river quicker and causing an enormous and rapid surge of river flow, increasing the potential for flooding.

Flood Hazard Areas

Flood hazard areas or floodplains are low-lying lands bordering streams, lakes and ponds and other isolated low lying areas into which high water spills during and after storm events. For flood insurance and regulatory purposes, the boundary of floodplains is defined as the elevation of flooding resulting from the 100-year storm. This 100-year statistical storm assumes that seven inches of rain will fall within 24 hours. The probability of such a storm occurring in any given year is one percent, or once every year. In reality, a 100-year storm event could happen more often, even more than once a year and has happened three times in the past fifteen years: in October 1996, June 1998, and March 2010.

The major floodplain in Brookline is located along the Muddy River from Ward Pond to Park Drive and Brookline Avenue. The nearby Longwood Medical Area in Boston and Brookline businesses and residents situated in or near the Muddy River floodplain have been greatly impacted by flooding. The damage costs from the storms in the late 1990s was over ten million dollars. In addition, areas around Sargent's Pond, Longwood Playground, the Robert T. Lynch Golf Course at Putterham Meadows, and Hall's Pond are mapped as 100-year floodplains. Because of the location of densely developed commercial and residential areas in the floodplain, the potential for property damage is significant.

Brookline participates in the Federal Emergency Management Agency's (FEMA) National Flood Insurance Program which is comprised of three components: flood insurance, floodplain management, and flood hazard mapping. Flood insurance is provided at a subsidized rate to homeowners, businesses, and renters in Brookline to cover disaster damage costs. In exchange, the Town has adopted and enforced floodplain management ordinances to reduce flood damage. In addition, the program identifies and maps the areas prone to flooding. There are numerous flood hazard zone designations. Zone A is the flood insurance rate zone that corresponds to the 100-year floodplains that are determined in the Flood Insurance Study by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no Base Flood Elevations or depths are shown within this zone. Mandatory flood insurance purchase requirements apply.

Wetlands

At the time of European arrival, wetlands, which include swamps, marshes, and wet meadows, were prevalent and large expanses of marsh existed along the Muddy River. The name of Cedar Swamp in the Cottage Farm areas implies that it was an Atlantic White Cedar Swamp, which is today a rare ecosystem in Massachusetts. Putterham Meadows was also an extensive area of marsh and swamp. Many parks such as the Emerald Necklace Park System, Griggs Park, Longwood Playground, and Amory Playground were constructed on former wetlands. Since most development in Brookline preceded the enactment of statutes to protect wetlands, large areas of these important resources were filled. Today, the major vegetated wetland systems are located at Hall's Pond, Lost Pond, D. Blakely Hoar Sanctuary, Allandale Farm, Sargent's Pond, off Dale Street, along the Hammond Pond Parkway, and at the Robert T. Lynch Golf Course at Putterham Meadows. While these areas have been significantly reduced, wetlands continue to provide important functions including flood control, storm damage prevention, pollution attenuation, and wildlife habitat. The Brookline Conservation Commission, comprised of appointed Town residents, is responsible for protecting, preserving, and preventing further loss of these important resources.

D. VEGETATION

In much of Brookline, the most obvious vegetation is grass, shade trees, ornamental shrubs, foundation plantings, and flowering plants. However, there are discrete areas of naturalized forest, wetlands, meadows and fields. No rare, endangered or threatened plant species have been identified.

Forest Land

Brookline's publicly accessible open space includes five forested areas which have naturalized vegetation and are managed minimally: Hall's Pond Sanctuary, which includes Amory Woods; D. Blakely Hoar Sanctuary; Lost Pond Sanctuary; Dane Park, and Putterham Woods. They range from 5 acres in the combined Hall's Pond and Amory Woods Sanctuary to over 59 acres in the combined Lost Pond Sanctuary, managed by the Town, and the adjacent State-owned Lost Pond Reservation.

The mature trees in all but Putterham Woods are primarily deciduous, and of mixed age and spe-

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cies, with pockets of conifers. Each of these areas includes large old trees, which probably predated the designation of that area as a park or conservation land.

Oaks and maples are present in all five areas. Other hardwoods common to these forested areas include cherries, birch, beech, and hickory. White pine and hemlock are the most common conifers. Understory trees and shrubs are mostly deciduous, and include a range of native and non-native woody plants typical of this part of Massachusetts as well as non-native species, which have naturalized. Blueberry, green briar, poison ivy, clethra, and witch hazel are among the common native woody plants. Non-native invasive woody plants found in our forested lands include *Ailanthus* (tree of heaven), Norway maple, buckthorn, Japanese honeysuckle, oriental bittersweet vine and multiflora rose.

Since these plants have grown on land that has been formerly managed for different purposes, and because they are separated by urban and suburban sections of Town, certain species common in one area are practically absent in another. At Hall's Pond Sanctuary, white willow, weeping willow, silver maple, and white ash surround the pond. Sassafras trees grow at Dane Park. Large yellow birch trees predominate one section of Lost Pond.

In addition to the publicly accessible wooded areas, there are pockets of woodland, and naturalized vegetation on private properties, including those protected by conservation restrictions. Private estates and institutions have grand specimens of native and non-native trees as well as forested lands that may be of considerable importance to wildlife habitat and biodiversity within the Town's borders. However, information about many of these is unavailable.

The site of the old Fisher Hill Reservoir, recently transferred in ownership from the State to the Town of Brookline, includes scrubby wooded sections along its edges, with much bittersweet, crabapple, and sumac. There is also a community of aspen, sphagnum, reeds, and *Phragmites australis* (common reed), a non-native invasive plant species, on the basin of the old reservoir. The area is currently used as wildlife habitat by foxes, rabbits, and other mammals, migrating and local birds, dragonflies and invertebrates. The Town plans to convert the reservoir into a multi-use park, which will include some wildlife habitat and passive, wooded areas.

Small herbaceous plants and wildflowers in these naturalized forest areas include many non-native species, particularly along the boundaries of private homes, yet there are many native wildflow-

Figure 5
The Value of Urban Trees

Conserve Energy

The USDA Forest Service found that trees properly placed around a building can reduce air conditioning needs by 30 percent and can save 20-50 percent in energy used for heating.

Mitigate Air Pollution

Trees filter particulates, extract automobile pollutants such as carbon monoxide and sulfur dioxide and return oxygen to the air.

Reduce Noise

Trees absorb and deflect noise generated by urban residents and act as a visual screen, providing privacy.

Improve Water Quality

Research conducted by the USDA Forest Service has found that the planting of trees means improved water quality, resulting in less runoff and erosion. This allows more recharging of the ground water supply. Wooded areas help prevent the transport of sediment and chemicals into streams.

Increase Property Value

The presence of trees alone raises the value of residential property. According to the USDA Forest Service healthy, mature trees increase a property's value by an average of 10 percent.

Moderate Climate

According to the U.S. Department of Agriculture one acre of forest absorbs six tons of carbon dioxide and puts out four tons of oxygen. This is enough to meet the annual needs of 18 people.

Create Wildlife Habitat

Trees provide food, nesting sites, and shelter for urban wildlife. The presence of wildlife contributes an unquantifiable value to the quality of life in urban areas.

Improve Quality of Life

"In laboratory research, visual exposure to settings with trees has produced significant recovery from stress within five minutes, as indicated by changes in blood pressure and muscle tension." Dr. Roger S. Ulrich, Texas A&M University

ers that have survived. Canada mayflower, white starflower and false Solomon's seal are among the most common in the sanctuaries.

Skunk cabbage flourishes at the D. Blakely Hoar Sanctuary in the wetland areas. Such plants are not found in Brookline's more formally maintained parks and recreational open spaces.

The preliminary vegetation assessment and management recommendations prepared by Urban Forestry Solutions in 2002 for the Parks and Open Space Division describes the overall health of these forests as good, apart from the Eastern hemlocks which have been suffering from infestations of hemlock woolly adelgids, an aphid-like insect pest. The Town has since taken measures to protect the hemlocks from further damage due to the woolly adelgid, by treating the infested trees with targeted applications of dormant oil, in accordance with proper pest management practices. The Town's forests constitute self-sustaining and natural-looking forests, although this report warns that the possibility of changes effected by human activity make all of these forested spaces potentially vulnerable to rapid changes.

Following the infestation of winter moth in the spring of 2004 and 2005, the Town's tree crews have continued to target affected trees with spinosad, the active ingredient in the specialty insecticide Conserve®, in accordance with proper pest management practices. These efforts have slowed the negative effects of this defoliating caterpillar, which has the capacity, if untreated, to cause severe damage to the health of Brookline's trees.

In July 2010, the Asian longhorned beetle (ALB) was discovered near the Boston/Brookline boundary. The potential presence of this non-native invasive insect in Brookline is a significant concern, since the ALB grows and reproduces within a wide range of deciduous hardwood tree species, affects both healthy and stressed trees, and eventually kills the trees. The U.S. Department of Agriculture, Department of Conservation and Recreation, City of Boston, and Town of Brookline are working together to address this threat, including surveying and inspecting trees in a regulated area around the site where infested trees were found. As of the end of 2010, the ALB had not been found in Brookline.

Recently, the Parks and Open Space Division has been working on an Urban Forest Master Plan to guide management efforts going forward.

Street Trees and Shade Trees of the Urban Forest

Street trees and the trees in public parks and open spaces, constitute a significant portion of Brookline's vegetation. The Town of Brookline currently has approximately 11,044 street trees and each year the Parks and Open Space Division plants approximately 200 new trees along streets and in parks.

The Town began tracking the number of street trees back in 1994, when a group of about 100 citizens volunteered to complete an inventory of all the Town's street trees. This inventory found that many areas of the Town did not have a sufficient number of street trees. This finding prompted the Tree Planting Committee, which directs the planting and maintenance of all of the Town's street trees, to start the Back-of-Sidewalk tree planting program. Since the creation of this program, the Town has expanded the diversity of street trees and planted trees where few existed before. Increasing the diversity of Brookline's street trees reduces the risk of blight, such as Dutch Elm disease, and provides a more varied look to the street. Species that have been planted include Japanese maple, magnolia, sweetgum, weeping cherry and Korean Mountain ash.

In 2009, the Parks and Open Space Division performed a complete update of all the street trees in its inventory, consisting of over 11,000 trees, and including information on tree species, size, condition and health, and management needs. The analysis of over health and condition of the trees showed that there were 83% Good, 14% Fair, 3% Poor, and <1% Dead. Species distribution was also found to be reasonably high, with the most common trees including, in order, Norway maple, red oak, linden, sycamore, honeylocust, red maple, pin oak, ash and elm, with over 40 additional species represented. The street tree inventory is an excellent management tool and continues to be used and updated on a regular basis to ensure that all of the information remains accurate.

Street trees are also susceptible to non-native invasive insects pests and pathogens. As with trees in Brookline's public forest land, affected street trees are regularly treated for winter moth. Street trees are also being surveyed for the Asian longhorned beetle (ALB), in the regulated area around the site where in infested trees were found in Boston.

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The Urban Forest Master Plan will also include assessment and management recommendations for Brookline's street trees and shade trees.

Agricultural Land, Fields and Meadows

Allandale Farm, located in both Boston and Brookline, is the last remaining working farm in the area, with both farmed and fallow fields. Open field and meadow habitat does occur elsewhere in Brookline, but is in almost all cases vulnerable to change and development. These include the formerly State-owned Fisher Hill Reservoir, which, under the Town's proposals for a park, will be excavated and re-landscaped. Currently, grasses and wildflowers grow there, such as goldenrod, Queen Anne's lace, and milkweed, providing habitat for songbirds, small mammals, and diverse insects, including fireflies, which generally do not re-populate an area which has been altered, and monarch butterflies.

Previously, an old-field habitat sloped down to Lost Pond from the old transfer station, and provided habitat for woodcocks and tree swallows, as well as for deer and wild turkeys, small mammals and diverse invertebrates. Although the field was disrupted by the capping of the landfill, regrading and new fill has created a sloping, new hill that is filling in with grasses. As succession progresses, this area may eventually include flowers, shrubs and other meadow and field plants, that will again provide wildlife habitat.

Wetland Vegetation

All of the publicly owned forested parks and sanctuaries include wetlands, as does Putterham Meadows. Lost Pond includes the remnant of a bog as well as a pond, stream, and wooded wetlands. The bog vegetation includes Atlantic white cedar, black spruce, sphagnum moss, and button bush. Water willow, a native plant, has been encroaching from the edges of the pond where the remnants of the bog are located, and non-native *Phragmites* border the pond near the landfill. A range of native plants, including cattail and buttonbush, provide habitat along the pond edges for spring peepers, wood frogs, spotted salamanders, ducks, and resident and migrating songbirds.

The South Meadow Brook emerges from a culvert in the Lost Pond Sanctuary. Much of the vegetation near its outlet is non-native, including garlic mustard and bittersweet. Increasingly large stands

of Japanese knotweed, a non-native invasive, grow beside Hammond Pond Parkway.

The red-maple swamp at the D. Blakely Hoar Sanctuary has classic vegetation for this ecosystem – studded with alder, skunk cabbage, and jack-in-the-pulpit and edged in high bush blueberries, sweet pepper bush and witch hazel.

The restoration of Hall's Pond introduced native aquatic vegetation to the section of wooded wetland and the wetland beside the outfall. These plant communities were intensively maintained until they were well-established, and are now flourishing. Pickerel weed, arrowhead, duck-weed are present. Although purple loosestrife has appeared, it is being removed as it appears. The Friends of Hall's Pond continues to hold volunteer clean-ups twice a year. A Hall's Pond Sanctuary Work Plan, developed collaboratively and approved by the Conservation Commission in 2010, ensures that vegetation removals, plantings, and other work and management activities are consistent with well-defined goals for the different sections of the sanctuary.

Dane Park includes a seasonal wetland, where dumping was once extensive, few native aquatics grew, and non-native flowers and groundcovers were prevalent. The Town removed much of the dumped matter in the past, and completed significant renovations to the park in 2010, including removal of non-native invasives and new native plantings. A new handicap accessible loop trail and a boardwalk to an overlook at a wet meadow, provide opportunities for visitors to view and appreciate the wetland and other vegetation.

Unfortunately, the dominant vegetation surrounding the Muddy River is non-native and is pushing out the native vegetation. Today the primary vegetation in the Muddy River area consists of common reed, *Phragmites*, which is choking the river with its deep roots and stalks, contributing to the flooding problem, and decreasing the habitat value for most wildlife.

Sites with Unique Natural Resources

Brookline's wetlands include certified vernal pools at the D. Blakely Hoar Sanctuary, Lost Pond, and adjacent to Hammond Pond Parkway, with sightings of spotted salamanders in other parts of Town. The certified vernal pool in D. Blakely Hoar Sanctuary is adjacent to a raised berm, with extensive wetlands extending into the sanctuary on the

opposite side as well. The vegetation on the Boston side of the berm is typical of a relatively urban red-maple swamp. Skunk cabbage, poison ivy, and catbriar are common. Biodiversity is limited in the herbaceous and understory layers. To those who do not understand or value wetlands, there is nothing to distinguish this spot. Spotted salamander egg masses in this certified vernal pool are usually attached to fallen tree branches, as there are few plants or woody vegetation within the pool itself, which eggs would normally attach to.

The parking lot of a large apartment complex in Boston is close to the border of the sanctuary; dumpsters and automobiles are parked right up to the vegetated edges, which show signs of dumping. People create access to the sanctuary by creating bridges and stepping stones of scrap lumber, fallen trees, and miscellaneous objects. The vernal pool, the upland habitat where the spotted salamanders spend most of their lives, and the areas they travel in the spring to get to and from the vernal pool are threatened by such uses, as well as by the new and larger houses and yards in Brookline that also border that part of the sanctuary.

Lost Pond and the surrounding wetlands have been certified as a vernal pool. Much of the surrounding upland habitat has been undisturbed and may sustain spotted salamanders. It is unclear if the renovations at Skyline Park and the landfill changed conditions for these amphibians, though a large area surrounding the pond remains largely undisturbed. Wood frogs and spring peepers still can be heard calling from Lost Pond in the spring.

Most recently, a vernal pool was certified east of Hammond Pond Parkway, approximately 2500 feet south of Route 9, in land owned by the State Department of Conservation and Recreation (DCR). Spotted salamander spermatophores and egg masses were documented, and breeding spring peepers were heard calling.

E. FISHERIES AND WILDLIFE

Wildlife

In spite of the urbanization of Brookline, there is a surprising diversity of wildlife. Birds, especially those in migration, benefit from proximity to water, relatively large tracts of undeveloped property, and the diversity of habitats, especially Brookline's rich collection of trees. Hall's Pond, Lost Pond, Walnut

Hills Cemetery, the Emerald Necklace parks along the Muddy River, and Skyline Park are among the favored birding spots in Brookline. The restoration of Hall's Pond in 2002 has increased nesting by Baltimore Orioles and Warbling Vireos, and visitation by herons, cormorants and grackles.

Owls, including Eastern Screech-Owls and Great Horned Owls, regularly nest throughout the Town, and Barred Owls are regular winter visitors. Indeed Brookline has one of the most dense populations of Eastern Screech-Owls in the Greater Boston area, with local hotspots including Fisher Hill, Heath School grounds, Putterham Woods, Larz Andersen Park, Skyline Park and Hall's Pond.

Certain bird species have adapted to the urban setting by taking advantage of specific urban habitats. For example, the Common Nighthawk, which is typically a ground-nesting bird, has in the urbanized northeast U.S. come to specialize in nesting on gravel rooftops, which provide a similar nesting substrate and protection from predators. Unfortunately, these birds are declining significantly throughout the Massachusetts and the rest of the Northeast, likely due at least in part to the demise of the tar and gravel method of roofing. Notably, Brookline is one of the very few places in Massachusetts that still hosts a population of nesting nighthawks. On summer nights, listen for their distinctive "peent" calls and the unique "boom" sound they make with their wings when displaying near a nest site. And look for their erratic flight and periodic dramatic swoops as they hunt insects around dusk. They're prevalent all along Beacon Street, from Washington Square through Coolidge Corner and St. Mary's, and can often be seen in the lights at Fenway Park. Another species of note is the American Kestrel, which is decreasing throughout the Northeast, perhaps as a result of lost farmland, but has taken to nesting in the eaves of buildings, making urban areas near open space – like Brookline – one of the kestrel's few remaining strongholds.

Birds commonly seen in Brookline throughout the year include native and non-native birds common to urban and suburban areas throughout the Northeast such as goldfinches, robins, cardinals, mockingbirds, crows, Red-tailed Hawks, chickadees, nuthatches, Downy Woodpeckers, Northern Flickers, Canada Geese, Mallards, starlings, pigeons, House Sparrows and Herring and Ring-billed Gulls, and the increasing Cooper's Hawk, Tufted Titmouse, Carolina Wren and Red-bellied Woodpecker. Song Sparrows, Gray Catbirds,

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Baltimore Orioles, Warbling Vireos, Yellow Warblers and, in smaller numbers, Rose-breasted Grosbeaks and Wood Thrushes breed in suitable habitats such as Hall's Pond, Lost Pond and D. Blakely Hoar Sanctuaries, greatly supplementing the spring and summer chorus. Other warblers, thrushes, vireos, sparrows and both Ruby-crowned and Golden-crowned Kinglets lend color during spring and fall migration, and the latter two sometimes make it through the winter. Dark-eyed Juncos, White-throated and American Tree Sparrows are popular at feeders and other suitable locations even in the dead of winter.

Several flocks of Wild Turkeys have taken up residence and are increasing in numbers. They are especially prevalent near the Longwood Mall, Tappan Street and Larz Andersen Park, and some are even so bold as to walk along Beacon Street. Majestic herons such as Great Blue, Green and Black-crowned Night Herons are commonly seen near water. Migration and winter brings to open water such as Hall's Pond, the Brookline Reservoir and the Muddy River, ducks such as Hooded and Common Mergansers, Buffleheads, Green-winged Teal and Black Ducks, plus coots and Pied-billed Grebes. Migration and winter is also when the local raptor populations of Red-tailed and Cooper's Hawk and American Kestrel are supplemented by Ospreys, Sharp-shinned Hawks, Merlins and even – rarely – Bald Eagles. Look for eagles whenever large groups of Canada Geese get in a tizzy.

The local feral Canada Geese population has been increasing significantly in recent years leading to some human-wildlife conflicts and potential conflicts and competition within goose populations. These geese are non-migratory, "resident" geese, and the Parks and Open Space Division has implemented an integrated goose control program to address the increasing population and to minimize goose issues in Brookline's parks and open spaces.

Mammals in Brookline include a variety of animals typically found in urban areas, such as Eastern gray squirrels, Virginia opossums, raccoons, striped skunks, mice and rats. Eastern chipmunks have become extremely common, even in the more urban sections of town. Eastern coyotes are common in Town and their population appears to be increasing, based on an increase in reported sightings across the Town. Coyotes have adapted to the urban and suburban environments, though they are typically shy. Red fox can be seen in various parts of Town and are sometimes mistaken for coyotes,

though they are smaller mammals. White-tailed deer have become established at Lost Pond, and in South Brookline, but have also appeared at the High School and at Hall's Pond and in many other sections of Town.

Rabbits can be seen in various parts of Town, and may include Eastern cottontails and New England cottontails, though the latter are in decline in Massachusetts due to habitat destruction and displacement by the adaptable Eastern cottontail. Voles, shrews, moles, and muskrats are present, though often overlooked. Woodchucks and porcupines are also likely to be present.

Fishers, large dark brown carnivorous mammals in the weasel family, are present in Town, though sightings are not common, since these animals are solitary and elusive. In recent years, fishers have been seen in the Fisher Hill area and between North and South Brookline.

Bats, particularly Little Brown Bats and Big Brown Bats, used to be common, but have declined precipitously due to White Nose Syndrome (WNS), a fungus that infects the bats and is mostly fatal. Scientists still know very little about WNS, but the disease has been spreading in recent years throughout New England and across the eastern United States and into Canada.

Amphibians and reptiles are not common in town, but can be observed. Garter snakes appear at Lost Pond, Dane Park, Hall's Pond, and other spots around town. Other species of snakes are likely to be found in Brookline as well. Painted turtles and snapping turtles can be found at Hall's Pond, Lost Pond, and D. Blakely Hoar Sanctuaries and Leverett Pond. Spotted turtles have been reported at Leverett Pond. These turtles were previously listed by the state's Natural Heritage and Endangered Species Program as a species of "Special Concern", but have recently been delisted.

Eastern red-backed salamanders are found in all the sanctuaries, and in many private properties. Spotted salamanders have been found at Lost Pond and D. Blakely Hoar Sanctuaries and in culverts near Dane Park and the Robert T. Lynch Golf Course at Putterham Meadows. Eastern newts are likely in Brookline as well. Wood frogs, spring peepers, and toads call from Lost Pond. Green frogs, American bullfrogs, and other toads and frogs can be found, but are not common.

Invertebrates include a wide variety that are commonly found in urban areas, such as spiders and many different insects, plus many invertebrates that are simply overlooked. Fireflies are seen in the wetlands, but are almost non-existent elsewhere in town. Eastern tiger swallowtails can be found, but are not common; monarchs pass through the town, but in decreasing numbers. Mourning cloak butterflies appear in the wooded sanctuaries after their winter hibernation. Dragonflies and damselflies are common in Brookline's wetlands, but are not often seen elsewhere in Town as they previously were. Within the Town's water bodies are diverse populations of aquatic invertebrates, and within the Town's soils are diverse populations of insects, worms and other invertebrates.

Vernal Pools

Brookline's wetlands include certified vernal pools at the D. Blakely Hoar Sanctuary, the Lost Pond Sanctuary, and most recently adjacent to Hammond Pond Parkway, with sightings of spotted salamanders in other sections of the D. Blakely Hoar Sanctuary and in other parts of town. Wood frogs have been heard at D. Blakely Hoar Sanctuary, but it is not clear whether there are wood frogs in other areas. Fairy shrimp may be in these vernal pools as well, and facultative species of invertebrates have been seen.

Spotted salamanders have been observed over the years at Lost Pond. The pond and the ring of wetlands surrounding it have been certified as a vernal pool. Salamander egg masses and salamander spermatophores have been documented within the pond itself. The sounds of wood frogs have been reported in this area as well.

A vernal pool was certified within the wetlands on the east side of Hammond Pond Parkway in January 2011, based on the presence of yellow-spotted salamanders, which were previously known to breed in these wetlands, but had not been documented.

Spotted salamanders have been reported in the wetland around the DPW facility and Dane Park, but egg masses have not been documented at this point.

Mating choruses of wood frogs and possible sightings of spotted salamanders have been reported in temporary pools within larger wetlands on private property at the end of Dale Street. Other

vernal pools may exist in Brookline on private properties.

Fisheries

The most recent fish community sampling conducted in 2002 in the Muddy River and Ward, Willow and Leverett Ponds show that numerous fish species live in these waterbodies, including bluegill, largemouth bass, American eel, common carp, goldfish, pumpkin seed, yellow perch, golden shiner, and pickerel (CRWA, 2003). While the fish population is up from previous decades and fish kills no longer occur because of removal of point source discharges of pollutants and other improvements to water quality, these fish species also illustrate that conditions in the waterbodies are still degraded; poor water quality as a result of stormwater runoff and illegal discharge of sewage to storm drains, low flows especially in the dry summer months, and erosion and sedimentation of their habitat. Classified as macrohabitat generalists, they can live in a wide range of habitats including lakes, streams, and ponds, do not require free-flowing water for any part of their life cycle and are the most pollutant tolerant and adaptable of the three fish classes. The two other classes of fish, which require free-flowing water for either all or part of their life cycle and are less pollutant tolerant, were not collected in the river or ponds.

Several fish studies conducted before the 2002 sampling effort had similar results with presence of common carp, golden shiner, pumpkinseed, and goldfish (Jones, 1996, and Maietta, 1990). However, fish were not found in the mid-1980s during a Harvard University study of the Riverway section of the Muddy River (Hartel, 1996).

In 1995, river herring, an anadromous fish species, were observed in Leverett Pond for the first time in many years (Bolduc, 1995), but has not been observed since. Anadromous fish species spend most of their lives in salt water, however, they swim to freshwaters, such as the Muddy and Charles River, to spawn and lay their eggs. Juvenile fish species spend about a year in the freshwater before swimming out to sea. Unfortunately the success rate of juvenile herring production is fairly low in the pond because of lack of suitable rearing habitat and poor water quality.

Due to contamination of the Muddy River from PCBs and mercury, the State Department of Public Health has issued several public health advisories

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warning that children younger than 12 years of age, pregnant women, women of childbearing age who may become pregnant and nursing mothers should not consume any fish. In addition the general public should not consume brown bullhead, common carp and American eel caught in the river and consumption of non-affected fish from the river should be limited to two meals per month.

The Brookline Reservoir is stocked annually with trout by the State Division of Fisheries and Wildlife. State fishing licenses are required to fish in the Reservoir.

Vegetated Corridors Suitable for Wildlife

Because there are many small open spaces connected by street trees and private gardens and plantings, the view of Brookline from an airplane reveals ribbons of green that appear almost continuous. These vegetated corridors, plus networks of wet areas and streams, serve as functional wildlife corridors for birds, flying insects, and mammals that have learned how to travel and survive in a territory that includes a patchwork of suitable habitat surrounded by extensive developed areas.

Larger areas with wildlife habitat that are contiguous or close to other areas with significant wildlife habitat are more valuable than isolated plots. Significant wildlife corridors include the Lost Pond Conservation Area, the DCR's Lost Pond Reservation and Hammond Pond Parkway and the City of Newton's Kennard Conservation Area and Park. Adjacent to Hoar Sanctuary are Leatherbee Woods and Hancock Woods, both preserved natural areas. The cemeteries on the border of Newton and West Roxbury and Kessler Woods in Newton conservation land add to the wildlife value of these lands.

The Emerald Necklace includes both Brookline and Boston. There are still possibilities for wildlife to move between Brookline, Jamaica Pond, the Arnold Arboretum, Franklin Park, and Forest Hills Cemetery.

There is some likelihood that deer, at least one moose, and other animals, such as coyotes and turkeys, have moved into Brookline by walking along the tracks of the D Line on MBTA's Green line, which pass through Hammond Pond Conservation Area in Newton.

Large holdings under private and institutional ownership remain as significant corridors for wildlife

movement, but have no protection as wildlife corridors. To be most effective, wildlife corridors should be part of large, contiguous properties. A narrow "greenway" that is protected for the pleasure of pedestrians and bicyclists is generally less effective in preserving native plant species and the animals that depend upon them. In large, untended open spaces, there is the potential for survival of valuable native plants that add to habitat value. However, when these areas are too far apart, opportunities for cross-pollination or vegetative reproduction are decreased. Less common native plants may decline, even if there is not a threat from human activities or from more adaptable or invasive plants.

Rare, Threatened or Endangered Species

The state Natural Heritage and Endangered Species Program has recognized the threespine stickleback (*Gasterosteus aculeatus*) as a threatened species found in the Babbling Brook area of Brookline. Brookline is also home to yellow spotted salamanders. Although these amphibians are not rare, their habitat is limited. It is possible that other rare or endangered amphibians or other organisms may be found in Brookline, though none have been documented at this point.

F. SCENIC RESOURCES AND UNIQUE ENVIRONMENTS

Unique Environments

Among Brookline's notable features are the attractiveness and vitality of the major commercial areas. For example, Coolidge Corner, Brookline Village, and Washington Square are valued as uniquely pleasant and accessible. They are adjacent to desirable residential neighborhoods and are walkable, accessible to bicyclists, and served by public transportation. Businesses include local services and unique stores, and meet diverse needs. Stores front the sidewalk and are generally small. The strong sentiment in Town to preserve the character of commercial areas contributes to the support for "green features" – such as street trees, flowers, small sitting areas, and amenities for pedestrians and bicyclists.

For many residents of Brookline, the unique landscape character of the Town could be described as "neighborhood character." Many of the diverse residential sections of Town share similar housing, have streets that seem to belong together, or are

unified by a local commercial area, a neighborhood school, a park or common meeting areas.

While some of these neighborhoods have commonly-used names or are named according to their local elementary school, park, or historic district, others are less clearly defined. Yet, residents have a sense of where their neighborhood is and what its character is and do not want their own neighborhood to lose its special features or become homogenized by change.

The variation across neighborhoods is exceptional. There are neighborhoods where large multi-family housing and an active street life are preferred, neighborhoods where small single-family houses are crowded together close to the sidewalk, others where they are placed suburban-style in the middle of a lawn with a prominent driveway. Other neighborhoods are comprised of older, expansive homes on large properties with landscaped and naturalized areas, some of which still remain from Brookline's estates.

The greenery in general and the street trees in particular are a highly significant and valued part of Brookline's landscape. The urban forest is subject to urban stresses, as well as invasive pests and stresses from climate change. In order to maintain our urban forest, consistent and sufficient levels of funding are needed.

Much of the sense of open space in Brookline's residential neighborhoods is tied to individual homes and the configuration of private yards, gardens, and street trees. These small areas are almost impossible to protect unless private owners and neighborhood associations understand the value of such spaces and owners take it upon themselves to maintain their properties with a concern for environmental benefits for themselves and their neighbors.

Parks, schoolyards, and other open spaces add to the landscape character of Town. Preservation of parks as neighborhood meeting places is one way to maintain the character of surrounding neighborhoods. However, proposals to change or upgrade parks for more specialized recreational uses or to attract more Town-wide use are often perceived as a threat to neighborhood character.

The largest, privately-owned properties with relatively undisturbed land in Brookline might include significant habitat and surviving populations of native plants and animals that have been extirpated

in the rest of Brookline. Without conservation restrictions on such properties, or acquisition by the Town or an environmental organization, there is little or no permanent protection for the habitat or the wildlife.

Open spaces with unique and scenic features in Brookline include our sanctuaries, parks, and publicly-accessible open spaces. Larz Anderson Park, Corey Hill Park, Skyline Park and, potentially, the park to be developed on the site of the Fisher Hill Reservoir all provide an expansive view of the sky and the skyline. Broad and scenic views, including views of the sky are also features of some of our larger parks and playing fields.

The Brookline Reservoir is unique in Town, with its attractive body of water and views of sky and skyline, its track for walking or running, and the surrounding park with significant trees and many benches. It is also particularly valuable as a place where seniors and others walk or visit together.

Dane Park's restoration highlights its geology, but this is the only geology trail in Town. Brookline holds many dramatic outcrops of Roxbury Conglomerate, known as "Puddingstone". Examples include outcrops in the Hoar Sanctuary, Hancock Village, and along Goddard Avenue. Except in sanctuaries, there is little protection of these geological features, and homeowners can potentially blast and remove rock formations if desired.

Open space in Brookline that interconnects with other open spaces, including that in other towns, is significant. The Riverway and the Emerald Necklace are nearly contiguous open spaces that give visitors many options. The complex of land including the Lost Pond Conservation Area, The Department of Conservation and Recreation's Lost Pond Reservation, Hammond Pond Parkway and the City of Newton's Kennard Conservation Area and Park, have been tied together better and made more accessible to the public by the creation of Brookline's new Skyline Park. The Hoar Sanctuary is adjacent to Boston's Leatherbee Woods and Hancock Woods. Unfortunately, access to these areas is difficult, except by car, and parking is extremely limited.

Because of Brookline's small size and diverse open spaces, it is important to improve access and promote the use of corridors between them, for example through greenways. Well-landscaped walking routes can have similar effects to parks and

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other open spaces, on health and well-being. Parks and conservation areas can serve as destination points or waysides along bicycle routes.

Historic Resources

Brookline has five local historic districts, as well as, sixteen National/State Register Districts and over 80 individual properties listed as Historic Places. Since 2000, 3 new historic districts have been added to this list: 1) Graffam - McKay 2) Chestnut Hill North and 3) Harvard Avenue local historic district.

The sixteen National/State Register Districts include: Olmsted Park/Emerald Necklace, Pill Hill/High Street Hill, Longwood, Cottage Farm, Brookline Village Commercial District, Town Green, Beacon Street, Beaconsfield Terraces, Chestnut Hill, Cypress Street/Emerson Garden, Graffam- McKay Development, Green Hill, Larz Anderson Park, Fisher Hill, Strathmore Road, and White Place. Sections of the Cochituate Aqueduct Linear District, Hammond Pond Parkway and West Roxbury Parkway have also been listed in the National Registrar of Historic Places.

The Emerald Necklace, on the border of Brookline and Boston, is one of Frederick Law Olmsted's notable designs. It is a significant landscape not only for its historic value, but also for its values to users and to wildlife. The Emerald Necklace also plays a significant role in stormwater management and flood control.

Other historic landscapes include the Walnut Hills Cemetery, and The Old Burying Ground, Linden Park and Linden Square, Emerson Garden, Town Green, Longwood Mall, Mason Square, Larz Anderson Park, Reservoir Park, Amory Woods, Hall's Pond, Fisher Hill Reservoir and Holyhood Cemetery.

The Paths of Brookline

Brookline's pathway system, primarily staircases linking the hills adjacent to Beacon and Washington Streets, is a valuable resource not only for pedestrian access but also as small corridors of open space. They should continue to be maintained and kept safe. They could also be enhanced by removing weedy species of trees and shrubs and replacing them with more indigenous plants that are more attractive. These paths are well described in the excellent walking guide by Linda Olson Pehlke's

book "Exploring the paths of Brookline." Each of the paths described in the book are located within the Brookline system and have been declared eligible (except Lawton) for the State and National Register.

Table 4
Brookline's Walking Paths

- 1) Addington Path
- 2) Beaconsfield Path
- 3) Carlton Path
- 4) Claflin Path
- 5) Clinton Path
- 6) Colbourne Path
- 7) Davis Path
- 8) Gardner Path (Oldest - established 2/8/86)
- 9) Lawton Path (Newest - established 4/13/72)
- 10) Marion Path
- 11) Mason Path
- 12) Rawson Path
- 13) Summit Path
- 14) University Path
- 15) Walnut Path
- 16) Winchester Path
- 17) Winthrop Path

Public Education for Visiting Open Spaces

A guidebook for walking among the parks and open spaces has also been proposed for North Brookline; it could be used in combination with Linda Olson Pehlke's, "Exploring the Paths of Brookline." The Chestnut Hill Garden Club's booklet, "Chestnut Trails: Nature Walks in Chestnut Hill," was published in 2001 and is still widely appreciated.

An Emerald Necklace Parks Map and Guide, the first complete map of the entire Emerald Necklace, was developed by the Emerald Necklace Conservancy and other park stewards including Boston Parks and Recreation, Brookline Parks and Open Space, Massachusetts Department of Conservation and Recreation, and Friends of the Public Garden, as well as other relevant organizations. The map and guide was first published in English in 2009 and later in Spanish, and has been extremely popular.

The Parks and Open Space Division has brochures with trail maps for each of the three nature sanctuaries. The Division also has an interactive park finder map on its website with links to park descriptions, at www.brooklinema.gov/Parks.

G. ENVIRONMENTAL CHALLENGES

Hazardous Waste and Brownfield Sites

In accordance with the Department of Environmental Protection's definition of brownfields being abandoned, leased or for sale parcels that are used for commercial or industrial purposes and/or contaminated sites, Brookline currently does not have any brownfield sites.

Landfills

Since the last Open Space Plan, the Town has capped the front landfill at 815 Newton Street, and moved the Department of Public Works operations to the back landfill. Extensive improvements, including a new active recreation field and community park, have been completed. In addition, the Town's Engineering Division worked with outside consultants to conduct environmental remediation on the adjacent properties, including removing significant amounts of ash, and re-landscaping large areas with new plantings. The back landfill still presents an environmental challenge for the Town of Brookline, and debris from the old landfill can still be found scattered and buried in parts of the Lost Pond Sanctuary. The full landfill closure plan, includes plans to clean up these areas.

Erosion

Changes to our landscape for the purposes of development leads to the removal of trees, ground-cover, shrubs and other vegetation, exposing the underlying soils to erosion. Erosion is the detachment of land surface material by rainfall impact and its subsequent removal by overland flow, or less significantly by wind impacts. In Brookline, the areas with the highest level of erosion are construction sites on previously undeveloped lands, especially those located on steep grades. Eroded soil is then transported by overland flow or stormwater runoff to the Town's surface water and wetland resources either directly or via catchbasins and stormwater pipes that eventually discharge to these waters. The eroded soil then builds up in the resource areas leading to sedimentation or build up of sediment in these areas.

Eroded soils are a significant source of pollution and degradation to our waters and wetlands. They carry other pollutants with them, smother and degrade benthic aquatic habitats and decrease the hydrologic or flood carrying capacity of the water-

body. The Erosion and Sedimentation Control By-Law passed by Town Meeting in June of 2004 provides a regulatory framework to control erosion on these sites.

Erosion can also occur along the water's edge of our streams, lakes and ponds. The lack of vegetation and stable soils along the banks of these waters and large, intense rainfall expose and removes the soil. Sections of the Muddy River banks are heavily eroded.

Flooding

Flooding has long been a problem along the Muddy River, Hall's Pond, and Griggs Park. These areas were historically larger wetlands that were heavily developed before the function and value of wetlands was properly understood and safeguarded. With increasing regularity, moderate rains necessitate emergency response measures to address storm water overflow. These events inspired a multi-jurisdictional park and public works project to restore the Muddy River's civil engineering structure, flood handling capacity, historic integrity and ecological vitality. The Town of Brookline, the City of Boston and various State environmental agencies, have undertaken this collective initiative to rehabilitate the Emerald Necklace parklands and restore the Muddy River system.

The Phase One Muddy River Flood Control, water Quality and Habitat Enhancement, and Historic Resources Preservation Project has begun with the Army Corp of Engineers underway in their design of this significant project (see map on pg. 50). Phase I of the Muddy River Restoration Project addresses flood control, water quality and wildlife enhancement, and historic landscape rehabilitation. The project saw increased activity in 2009 as the Army Corps Engineers moved the project forward and completed Phase I design. The first significant portion of the construction is expected to commence late in 2011.

The Conservation Commission monitors and regulates development within the 100-year floodplain to minimize property damage, and the Town participates in the Federal Flood Insurance Program.

Sedimentation

The impacts of sedimentation can be most readily seen at Leverett Pond, where the Village Brook outfall discharges at its eastern end. The

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Village Brook outfall carries stormwater drainage from both Brookline and Newton. About 100 feet from the outfall, there is a large sediment island or bar, which serves as a habitat for Canadian Geese and sea gulls and in the summertime has purple loosestrife. Pond depths between the outfall and the sediment bar are about one to two feet.

Geese have been observed in increasing numbers walking in this section of the pond. Leverett Pond will be dredged as a component of the Phase One Muddy River Flood Control, water Quality and Habitat Enhancement, and Historic Resources Preservation Project.

New Development Impacts

The US Environmental Protection Agency and the State Department of Environmental Protection have created and implemented a municipal stormwater discharge permitting system to manage stormwater runoff and minimize the impacts of erosion from construction sites. Subsequently, the Town has developed and adopted a Stormwater Control By-Law that includes provisions for construction site management and the adoption of erosion and sediment control practices. These regulatory efforts have reduced much of the movement of soils to our water and wetland resources.

Ground and Surface Water Pollution

All local surface waters suffer some degree of degradation through urban runoff, old sewer systems, combined sewer overflows (CSOs) and illegal dumping, which continue to introduce excessive nutrients, sediment, bacteria, and chemical pollutants, and low flows especially during the summer months, which exacerbate pollutant levels in the waters. These ongoing problems result in the accelerated growth of algae and aquatic plants, the spread of invasive, exotic plant species, the loss of wildlife habitat, offensive odors, and poor water quality.

Muddy River System

Historically, water quality in the Muddy River and its ponds has been poor. Yet over the past fifteen years, the health of the Muddy River and its ponds has been slowly improving because of concerted efforts by federal, state, and local government agencies to remove illicit connections from storm drain pipes, repair the stormwater drainage system, reduce sources of pollution and educate

the public about the impacts of stormwater runoff. When Olmsted proposed the Emerald Necklace parks, a major goal was to improve the sanitary conditions of the river, particularly the segment that was tidal at that time. Water quality monitoring by the Town and CRWA have shown that the river is safe for boating and has low levels of fecal coliform bacteria during periods of dry weather, however, high levels of fecal coliform bacteria, nitrogen and phosphorus (nutrients), and suspended sediment occur during and after a storm event when pollutants that have collected on paved surfaces are collected by stormwater and runoff to storm drains and catch basins. In addition, high bacteria levels can be attributed to the numerous illicit connections to the Town's storm sewer system and old faulty, failing infrastructures of the system. River bottom sediment quality is also very poor. Elevated levels of lead, mercury, petroleum hydrocarbons and polycyclic aromatic hydrocarbons have been measured in the sediment.

Also contributing to the degradation of water quality is the spread of *Phragmites*, a tall invasive exotic reed plant, which has also caused the loss of wildlife habitat and disrupted views of the Olmsted-designed park. Required by the federal Clean Water Act, the State has designated the Muddy River as an impaired or threatened water body for one or more uses and requires the development of total maximum daily loads (TMDLs) for the pollutants of concern. A total maximum daily load is the maximum allowable concentration of a pollutant that can be introduced into a waterbody and still ensure attainment of water quality standards and support designated uses. The river is impaired or threatened by the following pollutants: priority organics, metals, nutrients, siltation, organic enrichment/low dissolved oxygen, pathogens, oil and grease, taste, odor and color, and other habitat alterations.

Saw Mill Brook

The Charles River Watershed Association monitors the water quality of Saw Mill Brook for elevated bacteria levels that exceeded the State's boating standard during a slightly wet weather period and has found high levels, as well as high suspended solid levels, and low dissolved oxygen levels. The sources of wet weather contamination to the brook are unknown, however, possible sources could include waterfowl feces, pet waste and/or illicit connections. During the last five-year cycle watershed assessment of the Charles River watershed, the State also measured elevated levels of bacteria and

suspended sediment in Saw Mill Brook. Saw Mill Brook has been listed by the State as an impaired or threatened water for one or more uses and requires total maximum daily loads to guide clean up efforts in the subbasin. The pollutants of concern include other inorganics, organic enrichment/low dissolved oxygen, pathogens, taste, odor and color, noxious aquatic plants and other habitat alterations.

Hall's Pond

Prior to the restoration of Hall's Pond the pond was gradually filling and had poor water clarity due to the discharge of stormwater runoff directly to the pond. The Town designed the Hall's Pond Restoration Project, which was completed in 2002, to enhance and restore water quality and vegetation within and around Hall's Pond Sanctuary. Although the primary goal of the project was wetland restoration, a secondary benefit was improved stormwater management and better public access. The new stormwater diversion system reroutes stormwater flows, particularly the first flush, away from the pond. This by-pass system reduces the amount of sediment and contaminants accumulating within the pond, thereby improving the water quality. The new diversion system also enhances stormwater quality discharge to the Charles River.

Lost Pond

In 2003, the water quality and aquatic vegetation and wildlife communities of Lost Pond were assessed. Results of the surveys showed slightly elevated levels of bacteria and high levels of phosphorus, which were three to four times higher than the desired maximum concentration at four different locations in the pond. High nutrient levels in the small pond have resulted in eutrophication and the overgrowth of native (water willow) and exotic (purple loosestrife and *Phragmites*) invasive aquatic vegetation. Lost Pond will continue to be closely monitored during the ongoing landfill closure process to ensure there is no adverse impact to this wetland resource.

Willow Pond

Oil pollution in Willow Pond has been a continuing problem. Efforts are being made to locate and abate the source of the problem. An oil/water separator has been installed by the DPW in the storm drainage system upstream of the pond. In 1999, the site of the former Soule School and Highway Garage on Kendall Street was sold to a private

developer. The Town made arrangements with the developer and the Massachusetts Department of Environmental protection to install a groundwater remediation treatment technology. The Town has since sealed the drain line which crosses the site and installed an oil/water separator within the drain line down stream from the site. The Town will continue with the remediation of Willow Pond, which is scheduled for remediation with the overall Muddy River restoration project.

Impaired Water Bodies

The Muddy River is arguably the most impaired water body in Brookline; the proposed dredging of the Muddy River should help free the river system by deepening the river, upgrading flood control, removing invasive and exotic vegetation, improving fisheries/wildlife habitat and water quality. The restoration of the Muddy River will enhance recreational use of the Emerald Necklace Parklands. The restoration will also include improvements to the infrastructure that will involve repairing gatehouse controls, removing system-wide constrictions, replacing undersized culverts, and eliminating combined sewer overflows (CSOs). In addition, replanting natural vegetation is planned to enhance the environmental quality of the Muddy River system.

Invasive Species

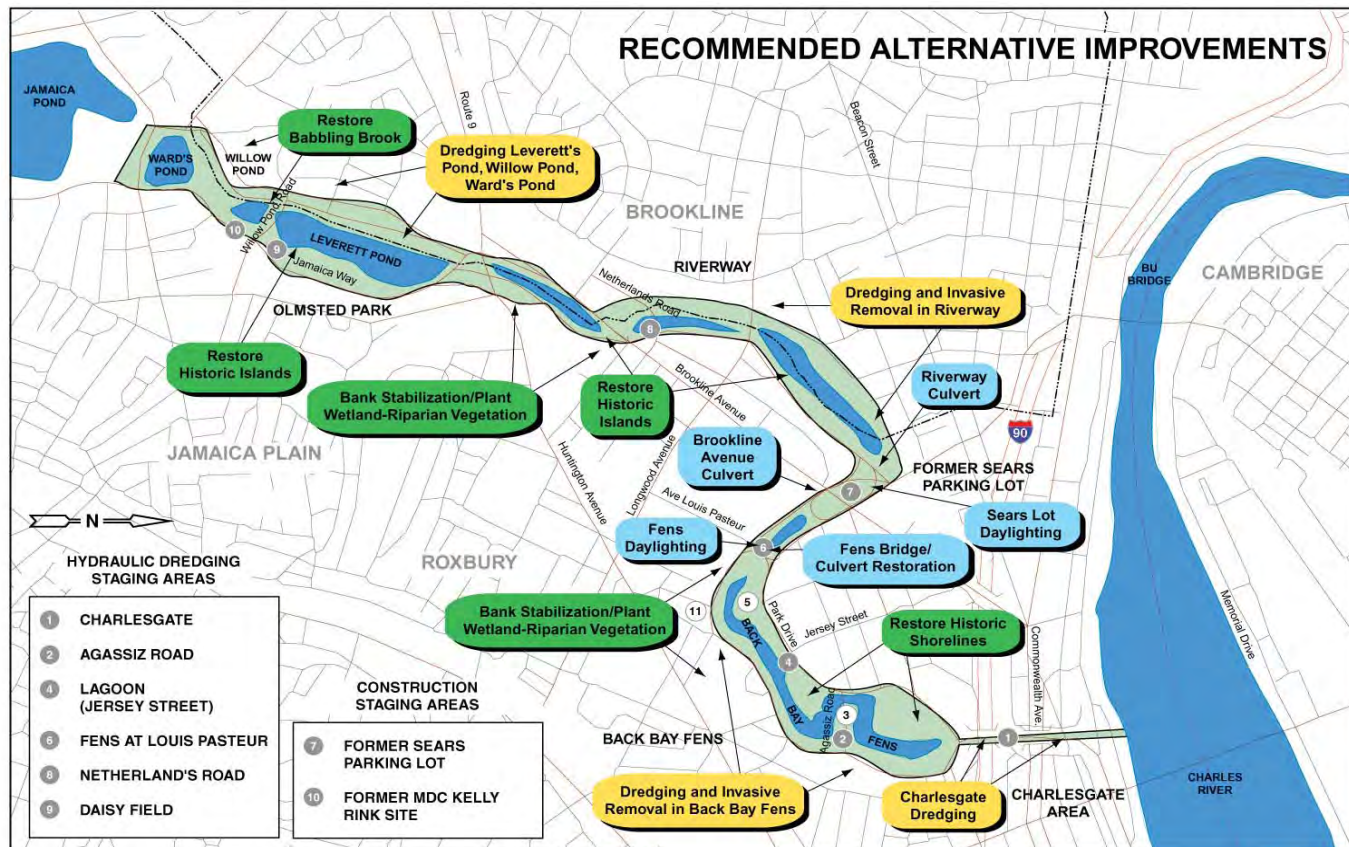
As noted in earlier sections, non-native invasive species continue to be a challenge for the Town of Brookline, as for all municipalities. Several invasives are known to be in Brookline already, and require careful management, including identification, appropriate removal, and appropriate restoration. For herbaceous plants, this includes species such as Japanese knotweed, garlic mustard, black swallow-wort, glossy buckthorn, and *Phragmites*, among many others. For woody plants and trees, this includes Tree of Heaven, and Norway maples, which the Town no longer plants. For insects and forestry pests, this includes winter moth and hemlock woolly adelgid.

Several invasives are known threats that are not currently present in Brookline, but warrant careful observation and planning to ensure they do not establish in Brookline, or can be treated quickly if found. For plants, this includes species such as mile-a-minute vine and kudzu, among others. For insects and forestry pests, this includes species such as the Asian longhorned beetle and the emerald ash borer, both of which attack trees. In addition

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to management strategies, the Town needs to continue to educate the community, so non-native invasives can be identified and controlled on both public and private land.

MUDDY RIVER RESTORATION PROJECT Riverway and Olmsted Parks



Source: CDM

"We want a ground to which people may easily go after their day's work is done, and where they may stroll for an hour, seeing, hearing, and feeling nothing of the bustle and jar of the streets, where they shall, in effect, find the city put far from them ... Practically, what we want most is simple, broad, open space of clean greensward, with sufficient play of surface and a sufficient number of trees about it ..."

Frederick Law Olmsted, Landscape Architect & Emerald Necklace planner/designer